CRA
ASSOCIATES INCORPORATED

PB 207 161

THE EFFECTS OF POLLUTION CONTROL ON THE NONFERROUS METALS INDUSTRIES

COPPER

Part I

Introduction and Executive Summary

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

Submitted to
The Council on Environmental Quality
Executive Office of the President
Washington, D.C.

CRA
CHARLES RIVER ASSOCIATES INCORPORATED · CAMBRIDGE, MASSACHUSETTS

December 1971

CRA

CHARLES RIVER ASSOCIATES INCORPORATED

THE ECONOMIC EFFECTS OF POLLUTION CONTROLS ON THE NONFERROUS METALS INDUSTRY: COPPER

Prepared for
the Council on Environmental Quality

Prepared by
Charles River Associates Incorporated
16 Garden Street
Cambridge, Massachusetts 02138

December 1971

TABLE OF CONTENTS

Preface. i

Part I

Chapter 1 -- INTRODUCTION AND EXECUTIVE SUMMARY 1

Overview of the Copper Market. 1

Trends in Production and Technology. 2

Consumption of Copper. 3

Structure of the Copper Industry 4

Copper Prices. 6

Government Policies. 8

The Copper Industry in the United States 9

Economic Effects of Pollution Controls on the Copper Industry. 12

The Net Costs to Producers of the Controls . . .15

Effects of the Controls. 18

Part II

Chapter 2 -- TRENDS IN SUPPLY AND THE TECHNOLOGY OF COPPER PRODUCTION 21

Introduction 21

The Primary and Secondary Industries 23

Geographic Distribution of World Copper Production. 26

Copper Production in the United States 31

Mining 31

Smelting and Refining. 32

Technology 34

Mining and Milling 34

Smelting 35

Refining 38

TABLE OF CONTENTS (Continued)

Chapter 3 -- CONSUMPTION OF COPPER. 40
Trends in Total Consumption 40
International Trade Patterns. 43
Copper Products 44
Refined Copper. 44
Scrap 48
Copper Alloy Ingot. 49
End Uses of Copper. 50
Substitution for Copper 54
Short-Run and Long-Run Substitution 54
Electrical and Electronic End Uses. 56
Chapter 4 -- STRUCTURE OF THE COPPER INDUSTRY . . 60
Concentration 60
Vertical Organization 70
Physical Distribution 74
Conditions of Entry 76
Chapter 5 -- COPPER PRICES. 82
Refined Copper-Price Quotations 82
Price History 86
The CRA Model of the Copper Market 93
Evidence on Price and "Income" Elasticities of Demand. 95
Chapter 6 -- GOVERNMENT POLICIES. 98
Copper Stockpile Program. 98
Trade Policies. 99
Price Controls. 101

TABLE OF CONTENTS (Continued)

Chapter 7 -- THE COPPER INDUSTRY IN THE UNITED STATES. 103

Geographical Distribution of the Domestic Industry. 103

Mining. 103

Smelting. 108

Refining. 111

Employment. 113

The Copper Producing Areas. 115

Arizona 115

The Other Copper Smelting States. 121

Financial Performance of the U.S. Copper Industry. 125

Part III

Chapter 8 -- ECONOMIC IMPACT OF POLLUTION ABATEMENT UPON THE COPPER INDUSTRY. . . . 130

Sources of Pollution in the Copper Industry . . 131

Costs of Pollution Abatement. 132

CEQ Estimates of Air Pollution Abatement Costs. 133

CEQ Estimates of Water Pollution Abatement Costs 136

CEQ Estimates of Total Abatement Costs. . . . 138

Other Factors Affecting Abatement Costs . . . 139

The Level of Capacity Utilization 139

The Tax Treatment of Abatement Costs. . . . 140

The Timing of Abatement Expenditures. . . . 141

Other Estimates of Control Costs. 142

Long-Run Impact of Pollution Abatement Costs on the Copper Industry 144

Probable Trends in the Copper Market In the Absence of Pollution Controls. 147

TABLE OF CONTENTS (Continued)

The Impact of Abatement Costs on the Copper Market. 149

Effects on Price, Production, and Consumption Under the Middle-Cost Assumption . . 150

Effects on Price, Production, and Consumption Under the High-Cost Assumption . . . 151

The Effects on the Copper Industry of Pollution Controls on Aluminum 153

The Effects of Off-Shore Smelting of U.S. Copper Ore 154

The Effects of the Controls on Existing Smelters. 156

Effects of Controls on U.S. Employment. . . . 157

The Regional Impact of Pollution Controls . . 158

Part III is our detailed analysis of the economic effects of imposing pollution controls on the copper industry.

Much of the information contained here was first published in Charles River Associates Incorporated, *An Economic Analysis of the Copper Industry* (Cambridge, Mass., 1970), which we prepared under contract with the General Services Administration. Data presented in this report if not otherwise attributed is taken from our GSA report.

PART I

Chapter 1
INTRODUCTION AND EXECUTIVE SUMMARY
Overview of the Copper Market

World production of copper in 1970 was 6.9 million short tons, an increase of 51 percent over 1960 production. U.S. mine production was 1.7 million short tons in 1970, an increase of 50 percent over 1960. In 1970, U.S. mine production amounted to 25 percent of world production and 30 percent of production in the noncommunist world. After the United States, the leading producing countries are the Soviet Union with 14.5 percent of world production and Zambia with 11.2 percent. Chile, Canada and the Democratic Republic of the Congo are also major producers.

The United States is the largest consumer of copper, consuming in 1970 more than 1.8 million tons out of a total world consumption of 7.3 million tons. Japan, the Soviet Union, and West Germany were the next largest

consumers, consuming about one-half of the U.S. amount.

Figure 2-1 shows the flow of copper-containing products in the copper market.[1] The primary industry, shown on the left, includes 7 integrated producers in the United States and about 30 in the noncommunist world, but is dominated by a few integrated firms including Anaconda, Kennecott, and Phelps Dodge in the United States.

Trends in Production and Technology

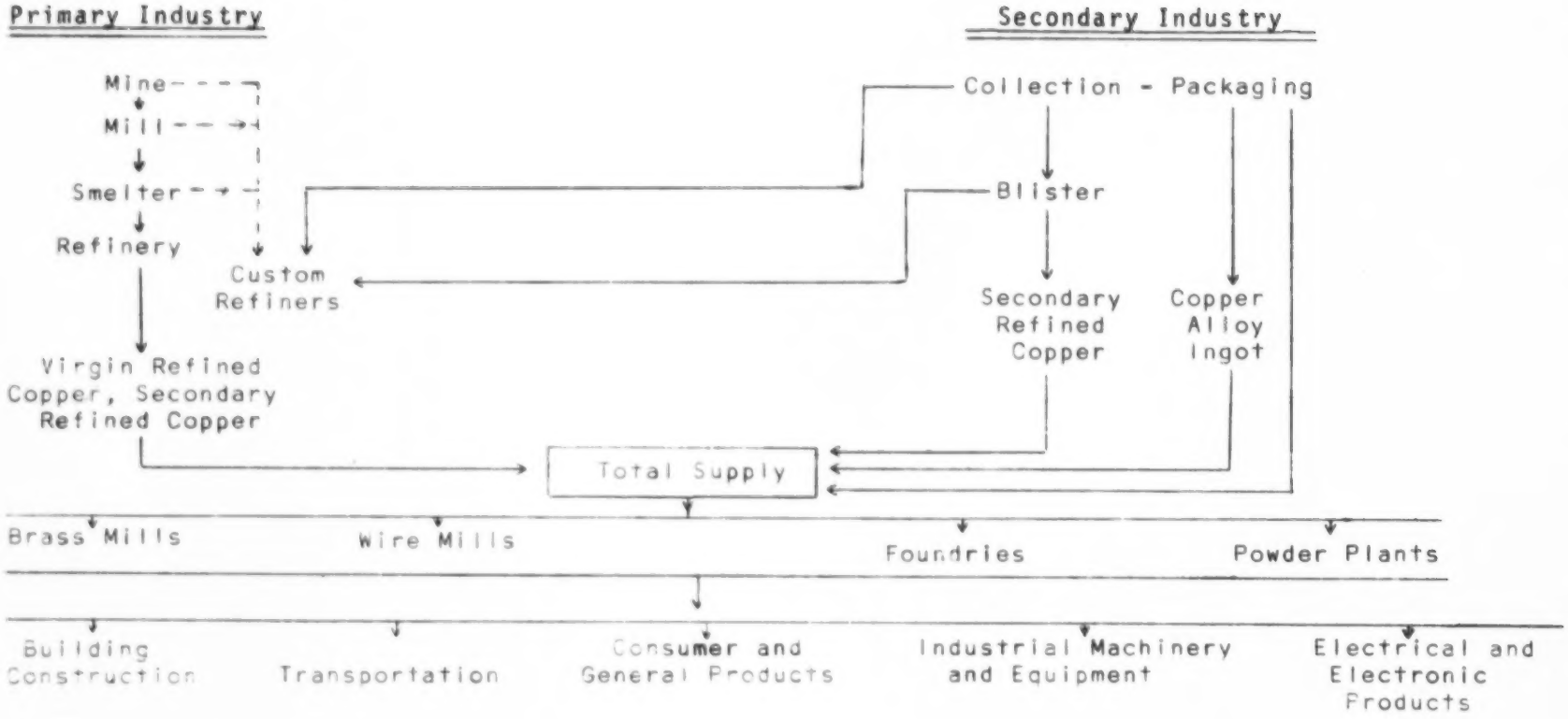
Chapter 2 of this report describes the primary and secondary copper industries, the geographic distribution of world copper production, production in the United States, and the technology of copper production. There are three main stages in the production of primary copper -- mining and milling, smelting, and refining. Ores are mined, usually by open-pit methods, and concentrated usually close to or at the mine site. Concentrates are transported to smelters and processed to produce impure copper metal which is known as "blister". There is a tendency in the United States and throughout the world for smelters to be located close to a mining area. The final stage is refining of the blister, usually by electrolytic deposition. Refineries tend to be located in areas where fabricators are concentrated.

Secondary copper is produced from scrap. Where the scrap is wholly copper secondary refined copper may be

---

[1]This figure from Chapter 2 of this report is reproduced here for convenience.

Figure 2-1
FLOWS OF COPPER PRODUCTS



CHARLES RIVER ASSOCIATES INCORPORATED

produced; secondary copper is indistinguishable from primary refined copper. Copper alloy scrap is not refined but is used in the production of alloy ingots. Scrap, depending on its form, may or may not require smelting.

The principal source of air pollution in copper production is sulfur dioxide emitted in the smelting of sulfide concentrates. Water pollution problems arise in electrolytic refining.

Consumption of Copper

During the 1950's, U.S. copper consumption fluctuated considerably from year to year and, on the average, tended to increase slowly. From 1962 to 1966 consumption increased rapidly, and although it has declined from its 1966 peak consumption is still far above the trend indicated by the 1950's. Copper consumption has tended to move in step with the Index of Durable Manufacturers, which represents the level of activity in some of copper's major end uses.

The principal markets for copper in the United States are electrical and electronic products (758,000 short tons in 1970), building and construction (574,000 tons), consumer and general products (546,000 tons), industrial machinery and equipment (439,000 tons), and transportation (303,000 tons). Bare wire and insulated wire are primarily consumed in electrical applications, while brass mill products and castings are distributed fairly evenly across user industries.

Copper is susceptible to a certain amount of short-run substitutions by ingot makers who can alter the proportions for metals in alloys, and certain users of small quantities of copper. However, the significant competition from other materials, especially aluminum, occurs over the long run, primarily as a result of investment decisions affected by long-run price expectations for copper and its substitutes.

During the past several decades the closest competition to copper has been aluminum, which has replaced copper in many electrical applications. The primary reason for this substitution has been the increasing price of copper relative to the price of aluminum.

In 1969 shipments from aluminum wire products amounted to 410,000 tons, an increase of more than 200 percent over a period of 12 years. In the same period, shipments of copper wire products increased to 1,294,000 tons, an increase of only 80 percent.

The most important area of substitution has been in power transmission and distribution. For example, aluminum has increased its share of the overhead distribution market from near 0 percent in the early 1950's to well over 90 percent in recent years.

Structure of the Copper Industry

Chapter 4 of this report examines concentration in each phase of the industry, the degree of verticle integration, the organization of physical distribution, and conditions for entry into the industry.

Five companies control about 90 percent of domestic refining capacity; the remainder is controlled by another five firms. The two major custom refineries -- ASARCO and AMAX -- are among the five largest domestic refineries. The other major refineries are also the three major primary producers, Kennecott, Anaconda, and Phelps Dodge.

The highly concentrated refined copper industry accounts for about 85 percent of total domestic copper supply (measured in cuprous content), with the relatively unconcentrated secondary industry accounting for most of the remainder. Secondary sources of supply include both secondary alloy ingot produced from copper scrap and scrap suitable for direct use by fabricators.

The noncommunist copper industry is fairly concentrated at the refinery stage. The eight-firm concentration ratio for the entire noncommunist world (including the United States) was recently measured to be about 63 percent; seven more firms account for an additional 17 percent. However, control of much of the capacity included in these figures has been altered as a result of nationalization and increased controls on foreign firms by several major foreign producing countries -- Congo, Chile, Peru and Zambia. Thus, the world primary copper industry is highly concentrated, although control of the facilities is currently in a state of flux.

The U.S. copper industry is characterized by a high degree of vertical integration, from ore mining through refining and frequently through fabrication and production of final products. Five primary producers, accounting for about 63 percent of U.S. ore

production, are fully integrated through at least the refining stage. Two custom refineries control the remaining 37 percent of refining capacity, 27 percent of smelting capacity and 5 percent of mine production. Two partially integrated primary producers control 7 percent of smelter capacity and 10 percent of mine production. Except for 11 percent of mine production, these 12 firms control the entire domestic primary industry.

The degree of vertical integration in foreign countries is similar to that of the United States, but is less complete. Most foreign ore producers are integrated through the refining stage, but a much smaller percentage than in the United States is integrated through fabrication.

Physical distribution is performed, by the most part, by the refineries. Roughly 80 to 85 percent of primary refined products are transferred by producers to their own fabricators. The remaining production is marketed primarily by merchants, who purchase scrap and ore from small copper mines and smelters and have it refined on a "toll" basis, although small quantities are sold on the Commodity Exchange (COMEX) and the London Metal Exchange (LME).

Copper Prices

There is no single price which can clearly be labelled "the" prevailing world price of refined copper. There are several "producer prices", two important

average prices, the merchant or "outside price", and the LME and the COMEX prices. The most important U.S. prices are the domestic producer price and the custom smelter price, while the most important foreign price is the LME price. The custom smelter and LME prices are transaction prices at which any consumer can purchase copper; in the frequent domestic rationing periods the domestic producer price represents the price at which favored consumers can purchase copper from the domestic producers.

In general, during the past 20 years copper prices have not increased substantially relative to other industrial materials (although they have increased relative to aluminum price). The LME price rose to a peak of $0.52 in 1956, fell to a low of $0.21 in 1958, was steady at about $0.30 from 1959 through 1963 then rose to about $0.82 in 1966. Since then it has fluctuated between $0.35 and $0.77 and is currently at about $0.48.

The domestic producer price has followed the same overall trends as the LME, but has been more stable. It has tended to lag behind the LME price during periods of rising prices; prior to 1963 it was generally not more than $0.08 above or below the LME price. However, in 1964 when the LME price began its rise towards the 1966 peak of over $0.80 the producer price rose only moderately and wide differences between the two prices existed for most of the 1964 to 1970 period. The highest level reached by the producer price was $0.60 in 1970.

It is quite obvious that U.S. producers believe it to be in their interests to keep copper prices low and

stable. Their principal concern has apparently been that high prices of copper will induce substitution of aluminum and other materials for copper in the long run and that their lost markets will not be regained by a future decline in copper prices.

During periods in which producer capacity is insufficient to meet demand at the producers' price, the producers have chosen to ration copper instead of to raise the price to the short-run market-clearing level. Of course, rationing at low prices may be just as strong a stimulus for long-run substitution as unlimited sales at high prices.

The LME price is determined in an open auction marketplace, and in this sense is clearly a free market price. However, the foreign copper market is fairly concentrated, although less so than in the United States, and there is evidence that the foreign producers recognize their mutual interdependence in the market. As a result, in some periods of weak demand the foreign producers have supported the LME price by mutual output reductions. There is also evidence that the foreign producers may share the domestic producers' concern over long-run substitution away from copper that might be induced by high prices.

Government Policies

The U.S. government has directly affected the copper industry through stockpile purchases and sales, price controls, trade policies, and subsidization of exploration.

As of September 1971, the government had 252,000 tons of copper in its stockpile, only about one-third of the objective. During the decade after World War II the

stockpile grew to levels substantially above the government's objective, but the stockpile has been drawn down during the years of short supply.

The tariffs on primary copper have generally been low in the United States as they have been in most major copper-consuming countries. Domestic tariffs on crude copper, blister, and scrap were suspended in 1966, and the materials are therefore exempt from the 10 percent import surcharge. The suspension expires in June 1972. Tariffs are in effect on refined copper, but the full amount of the import surcharge is not applied since an international agreement limits the total duty to not more than the 1930 tariff.

The U.S. government has at times placed severe quota restrictions on the export of refined copper and scrap. These restrictions explain in part why it is possible for large differences to exist between the domestic producer price and the LME price.

The recent price freeze has not affected refined copper prices. The price ceilings determined by the Economic Stabilization Act of 1970 are the prices of May 25, 1970, which are considerably above current levels.

The Copper Industry in the United States

The principal copper producing states are Arizona, Utah, New Mexico, Montana, Nevada, and Michigan. These states produce 97.5 percent of domestic production. Arizona produces 53 percent and Utah 17 percent. Copper

mining employed 37,000 in 1970 including 29,500 production workers.

Total U.S. smelter capacity is 9.2 million tons of charge. Smelting is concentrated in Arizona, which has 49 percent of capacity and 8 of the 19 smelters. Utah and Montana each have 11 percent of capacity. Other states having smelters are Washington, Texas, Michigan, New Mexico, Nevada, New Jersey, and Tennessee.

Refining capacity in the United States is 2.7 million tons per year, of which 2.3 million tons is electrolytic. Refining is less regionally concentrated than mining and smelting. Maryland has 26 percent of tank capacity, New Jersey has 21 percent and Texas has 18 percent. Other states having electrolytic refineries are Montana, Utah, Washington, New York, Arizona, and Missouri. Coke and fire refineries are located in Michigan, New Mexico, Texas, New York, and New Jersey.

Chapter 7 of this report presents data on employment, general input cost statistics, value added and value of shipments for the aggregate production of U.S. smelters and refineries.

The state most likely to be affected adversely by pollution abatement costs is Arizona. The mining industry is the state's second largest source of income and copper contributes over 90 percent of mining income. The income for copper in 1969 was $860 million.

Arizona smelters employ between 2,500 to 3,500 people in Arizona. Wages paid to mining and smelting employees in 1970 amounted to $202 million. The copper industry is one of the largest consumers of the

construction and transportation industries' outputs in the state and supports much of the state's retail trade and services.

Three smelters, accounting for 21 percent of U.S. smelter capacity, are located in Gila County -- two in Hayden and one in Miami. Two smelters are located in Pinal County which adjoins Gila, one at San Manual, the other at Superior. There are plans for closing the Superior smelters and enlarging the San Manual smelter. A mine-mill-smelter complex at Morenci is the principal employer in Greenlee County. A smelter at Douglas in Cochise County may shut down; pollution controls may be a factor in determining whether or not this occurs. The Douglas smelter employs 645 persons and has a payroll of $6 million. The population of Douglas is 12,300. An eighth smelter is located at Ajo in Pima County, the county in which Tucson is situated.

Copper mining is extensive throughout Arizona, and the economies of four counties rely greatly on it -- Graham, Mojavi, Yavapai, and Yuma.

The primary copper smelters in other states are generally not crucial elements in their state's economies, although they are important to the cities where they are located (except possibly for Tacoma, Washington and El Paso, Texas, which are large cities with employment distributed among several industries. The Tacoma smelter may be closed if the owners and the local air pollution control authority cannot reach agreement on control standards. Closing the Tacoma smelter would affect mining employment in Arizona),

A smelter in White Pine, Michigan is in the peculiar position of having too little sulfur in its feed. Apparently the result is that satisfying the 90 percent emission standard is more difficult than for most smelters and may be infeasible.

A table in Chapter 7 shows summary statistics on the financial performance of major domestic producers. Generally the firms have annual sales on the order of $0.5 to $1.0 billion. Most report net income of considerably above 10 percent of stockholders' equity, but two firms reported net 1970 income of only 5.4 percent of equity.

Economic Effects of Pollution Controls on the Copper Industry

According to CEQ estimates the additional capital costs of meeting air quality at copper smelters by 1976 will be $313 million and $28.1 million will be required to meet water quality standards at electrolytic refineries. The CEQ data are presented in Tables 8-1 and 8-2 from Chapter 8 of this report.[1] CEQ states that under reasonable assumptions the air pollution abatement costs could be 10 percent lower or 100 percent higher than the estimates, and water pollution costs could range from 25 percent below the estimate to 130 percent above. The CEQ estimates of capital costs for air pollution abatement are lower than industry estimates and estimates reported by the Bureau of Mines. A comparison of these three estimates is made in Chapter 8 of this report.[1]

---

[1]Reproduced here for convenience.

Table 8-1
CEQ ESTIMATES OF COSTS OF CONTROLLING
SO_2 EMISSIONS AT COPPER SMELTERS
(Millions of Dollars)

Costs of Controls	1972	1973	1974	1975	1976
Cost to control existing facilities	13.3	26.6	93.2	106.5	26.6
Cost to control new facilities	9.3	9.4	9.4	9.4	9.4
TOTAL	22.6	36.0	102.6	115.9	36.0
Annual Costs					
Operation & Maintenance	1.7	5.2	17.3	31.0	34.5
Interest	1.6	4.7	15.6	28.0	31.3
Depreciation	1.1	3.3	11.0	19.8	22.0
TOTAL	4.4	13.2	43.9	78.8	87.8

SOURCE: CEQ

ASSUMPTIONS:

1. Fifteen copper smelters were assumed to require control.
2. The interest rate is 10%, including 2% for taxes and insurance.
3. The growth rate of production is 2.67% per year.
4. The depreciation rate is 7% per year.
5. No downtime for installation is envisaged.
6. The investment costs to control existing facilities are phased over the five years -- 5%, 10%, 35%, 40%, 10%, and the investment costs of controlling new facilities are assumed to be linear.
7. No credit for acid by-products was assumed.

(Assumptions continued on following page.)

Table 8-1
CEQ ESTIMATES OF COSTS OF CONTROLLING
SO_2 EMISSIONS AT COPPER SMELTERS
(Millions of Dollars)

(continued)

8. Three smelter models were used:

   Model Plant A (Configuration -- 1 Roaster, 1 Reverberatory Furnace, and 2 Converters) with production of 75,900 tons of copper per year and 45% present sulfur control. The control scheme involved is limestone scrubbing.

   Model Plant B, with production of 75,900 tons of copper per year, 6% present sulfur control, and a control scheme involving an acid plant preceded by a dry precipitator.

   Model Plant C. (Configuration -- 1 Reverberatory Furnace, and 4 Converters) with production of 50,000 tons of copper per year and 10% present sulfur control, and a control scheme involving an acid plant preceded by a dry precipitator.

9. All plants were assumed to operate at 100% capacity, 24 hours a day for 330 days of the year.

Table 8-2
COSTS OF CONTROLLING WATER
POLLUTION IN COPPER REFINING
(Millions of Dollars)

Investment Costs	1972	1973	1974	1975	1976
Cost to control existing facilities	3.98	4.19	4.39	4.60	4.82
Cost to control new facilities	1.13	1.17	1.21	1.26	1.30
TOTAL	5.11	5.36	5.60	5.86	6.12
Annual Costs[1]					
Operation & Maintenance	0.78	1.56	2.36	3.16	3.98
Interest	0.41	0.84	1.29	1.75	2.24
Depreciation	0.26	0.52	0.80	1.10	1.40
TOTAL	1.45	2.92	4.45	6.01	7.62

[1]Annual costs have been adjusted to include the annual costs of the "new facilities" covered in "Investment".

SOURCE: CEQ

ASSUMPTIONS:

1. Copper refineries would apply equalization, coagulation, sedimentation, flotation, and neutralization to 100% of process wastewater.
2. The interest rate is 8%.
3. The growth rate of copper production is 4.2%.
4. The depreciation rate is 5% per year.
5. Some downtime for installation is included.
6. The investment costs are phased on a straight line basis from 1971 to 1976.

Using the CEQ data the following is the estimated range of per-pound abatement costs for air and water pollution.

ABATEMENT COSTS FOR PRODUCING REFINED COPPER
(Cents per Pound)

	Low	Middle	High
1972	0.1	0.1	0.3
1973	0.3	0.5	1.0
1974	1.3	1.4	2.8
1975	2.0	2.2	4.5
1976	2.2	2.5	5.0

In 1970 total U.S. industrial consumption of copper was 2,971,000 short tons and net stock accumulation and exports were 139,200 short tons. Total U.S. primary copper production was 1,360,300 short tons. A reasonable scenario for long-run trends in the copper market without abatement costs is that consumption will grow at about 3.8 percent per year, supply will grow at about 3.6 percent per year, and price (in real terms) will rise at about 1 percent per year. Projecting supply and demand at these rates yields estimates that in 1980 consumption will be 4,250,000 tons, supply (including scrap supply) will be 4,169,000 short tons, and the producer price will be about $0.64 per pound in real terms.

We must emphasize that these figures should not be interpreted literally, but merely serve as a useful base for the impact analysis. The copper market is extremely

complex even under "normal" conditions. The behavior of the domestic producers in rationing copper for long periods of time at below-market prices is particularly difficult to analyze. It is clear that if these conditions persist in the future, the U.S. producers could increase the price of copper without inducing substantial foreign competition in the U.S. market. This conclusion would be obviously true during periods of rationing in the United States; during these periods U.S. producers could raise the list price of copper without any loss in sales. This conclusion might also be valid even during periods of nonrationing, as some participants in the copper market (the Chilean government for example) have in the past expressed strong desires to increase the price of copper.

Unfortunately, it is impossible to forecast accurately the extent to which the foreign market will interact with the U.S. market. Even under "normal" market conditions it is impossible to predict the extent to which domestic producers will ration copper during the next decade. In addition, the copper market is currently undergoing radical changes in its structure caused by the increasing decision-making role of national governments in copper production. This factor could completely alter the production behavior of foreign supply.

As a result of these considerations, in our impact analysis we present a range of results, calculated under two extreme assumptions: (1) that foreign copper does not compete in the domestic market and an equilibrium price is achieved, after imposition of abatement costs,

which equates domestic demand and domestic supply; and (2) that foreign competition prevents any increase in price as a result of abatement costs. The first case can arise if the two-tier price system is still in effect in 1980, as in that case producers can increase their price by the full amount of control costs without stimulating an increase in imports. This case can also arise even if the two-tier price system is not in effect if foreign producers refrain from expanding their output when the domestic producers raise prices. In the second case we make the equally extreme assumption that any increase in prices as a result of abatement costs will cause such a flood of imports that the increased price cannot be maintained. The actual impact of the abatement costs should be somewhat in between these two cases.

The analysis is also performed using both the middle- and the high-cost estimates provided by CEQ. No analyses were performed using the low-cost estimates, as these cost estimates are very close to the middle-cost estimates and therefore would yield essentially the same results in the impact analysis.

The Net Costs to Producers of the Controls

The net cost to producers of pollution controls can usefully be defined to be the net reduction in after-tax profits as a result of the controls. The before-tax net cost has two components: the reduced profits per unit on the copper that is actually sold and the profits foregone on sales that are lost as a result of the higher prices.

The reduction in domestic production in the various scenarios we have considered above ranges from 87,000 to 332,000 short tons, as indicated below (short tons):

	Little Foreign Competition	Severe Foreign Competition
Middle-Cost Assumption	84,000	162,000
High-Cost Assumption	173,000	332,000

With the middle-cost assumption, if there is severe foreign competition the increase in production costs would not be offset by price increases and there would be a resultant decline in supply in the long run of 6.9 percent. On the other hand, if there were no foreign competition, prices could be increased with the result that supply would increase. Assuming no increase in imports, supply and demand would be equilibrated at a price 4 percent above the no abatement cost case; under our assumptions by 1980 the price would rise to about $0.66 in 1970 dollars.

The effects on price, production, consumption, and imports under the two assumptions about foreign competition can be summarized as follows:

LONG-RUN EFFECTS ON THE COPPER MARKET
OF AN INCREASE IN COSTS OF $0.025 PER POUND

	Little Foreign Competition	Severe Foreign Competition
Producer Price of Copper in 1980 (1970 dollars/lb.)	$0.66	$0.64
U.S. Supply of Primary Refined in 1980[1] (thousand short tons)	2251	2173
U.S. Supply of Secondary Refined and Scrap in 1980 (thousand short tons)	1768	1708
Net Imports of Copper in 1980 (thousand short tons)	36	369
U.S. Consumption of Copper in 1980 (thousand short tons)	4055	4250

[1]About 56 percent of total copper supply is assumed to be primary copper, the remainder refined and unrefined scrap.

According to the high-cost assumption the long-run pollution abatement cost is $0.050 per pound of copper. With severe foreign competition there would be no price increase and the assumed supply rate would be 14.2 percent below the no abatement cost supply rate. Domestic consumption would not be affected and the undersupply would be made up by imports. In the case in which there is no foreign competition the price of copper would rise by 8 percent, to about $0.69 per pound, at which point domestic demand would approximately equal domestic supply. The effects on the market in the high-cost case are summarized below.

.050

LONG-RUN EFFECTS ON THE COPPER MARKET
OF AN INCREASE IN COSTS OF ~~$0.50~~ PER POUND

	Little Foreign Competition	Severe Foreign Competition
Producer Price of Copper in 1980 (1970 dollars/lb.)	$0.69	$0.64
U.S. Supply of Primary Refined in 1980[1] (thousand short tons)	2162	2003
U.S. Supply of Secondary Refined and Scrap in 1980 (thousand short tons)	1698	1574
Net Imports of Copper in 1980 (thousand short tons)	8	673
U.S. Consumption of Copper in 1980 (thousand short tons)	3868	4250

[1]About 56 percent of total copper supply is assumed to be primary copper, the remainder refined and unrefined scrap.

Effects of the Controls

An important effect of abatement costs may be to induce U.S. concentrate to be shipped to foreign smelters and re-imported as copper metal. A complete analysis of that possibility was beyond the scope of this study, but it appears that this possibility may begin to become attractive for abatement costs of $0.02-0.04 per pound or higher. As the CEQ cost estimates are in the range of $0.022 to $0.050 per pound, this possibility may well arise.

Even if U.S. abatement costs are high enough to make exportation of U.S. concentrate attractive, these

costs will probably not in general be great enough for U.S. producers to shut down existing smelters, although a few marginal smelters might be forced to close. Therefore in the most extreme case there would be not expansion in U.S. smelting capacity from its present level of 1,730,000 short tons; once production reaches this capacity all additional concentrates production would be exported. Depending on the assumptions made about control costs and foreign competition, we found earlier that domestic copper production in 1980 with pollution controls would be between 2,000,000 and 2,250,000 short tons. In our most extreme scenario in which no new domestic smelter capacity is constructed, between 270,000 and 520,000 short tons of copper would be exported in 1980 for processing by foreign smelters. We caution, however, that with the available data we can make no judgment about the likelihood of this scenario.

If the aluminum price increases as a result of controls, the effects of controls on the copper industry could be moderated. However, the actual impacts of the controls could still conceivably be near the upper end of the range estimated above. If copper control costs are near the upper end of our assumed range they would be substantially greater than the aluminum control costs. Further, the effects of foreign competition could almost be as severe with higher aluminum prices as they would with lower aluminum prices.

The pollution controls will probably not cause any long-run decline in employment of the domestic copper industry from its 1970 level of about 54,000 employees. However, there may be some immediate, localized decline

in employment if some marginal smelters or mines are forced to close down. Depending on assumptions made, the decline in employment from levels that would otherwise be attained by 1980 ranges from 2,770 to 10,900 employees.

It appears that in general most existing smelters in the United States will continue to operate after imposition of pollution controls. Nevertheless, one firm appears likely to close a major custom smelter in the Pacific Northwest if the local pollution control regulations are implemented and another firm has already decided to close a custom smelter at Douglas, Arizona.

The state most likely to be affected adversely by pollution abatement costs is Arizona. The mining industry is the state's second largest source of income and copper contributes over 90 percent of mining income. The income for copper in 1969 was $860 million. Copper mining is extensive throughout Arizona and the economies of four counties depend greatly on it. In addition, there are 8 smelters in Arizona, located in 5 counties.

This is one of four reports prepared by
Charles River Associates
for the
Council on Environmental Quality
on: Aluminum
Copper
Lead
Zinc